

# Buffalo's Light Rail Vehicle

BEN J. ANTONIO, JR.

**B**uffalo's 6.4-mi light rail transit line depends on a fleet of 27 four-axle, double-ended cars. The Niagara Frontier Transportation Authority (NFTA) uses a work order system to monitor failures in service, failures found during monthly preventive maintenance, and failures discovered during system checks. Now in the form of a computer data base, this system allows NFTA to keep a history of each vehicle and to estimate repairs, distances traveled between failures, and parts needed for repairs. After 2 million vehicle fleet miles logged since 1985, NFTA has been able to keep more than 95 percent of its fleet available for service at any given time. Aiding this effort is a maintenance strategy incorporating quick connec-

tors, parts interchangeability, and an ample parts supply. Also important is the maintenance employees' familiarity with the light rail vehicles (LRVs). Because the Japanese-made LRVs had to have some U.S.-made parts to satisfy federal procurement regulations, buying replacement parts has been difficult and costly. And, since the warranty on the LRVs expired, resolving problems with the manufacturer has been very difficult. Recommended improvements in the procurement process include involving maintenance personnel in discussions about system requirements and including the spare parts needed to support the system in the overall LRV procurement.

BUFFALO'S LIGHT RAIL TRANSIT (LRT) line is 6.4 mi long, 1.2 mi of which is above ground (see Figure 1). The above-ground section of the rail line is a free-fare zone and runs from Auditorium Station to Theatre Station. It is considered one of the longest transit malls in the country. Except for emergency vehicles, only the light rail trains are allowed in the mall area.

Six passenger stations are incorporated in the mall area. They feature handicap loading ramps and low-level loading from 6-in. platforms. To accommodate the low-level loading, each car is equipped with folding steps that are deployed only at the above-ground stations.

*Metro Rail, Niagara Frontier Transportation Authority, 164 Ohio Street, Buffalo, N.Y. 14203.*

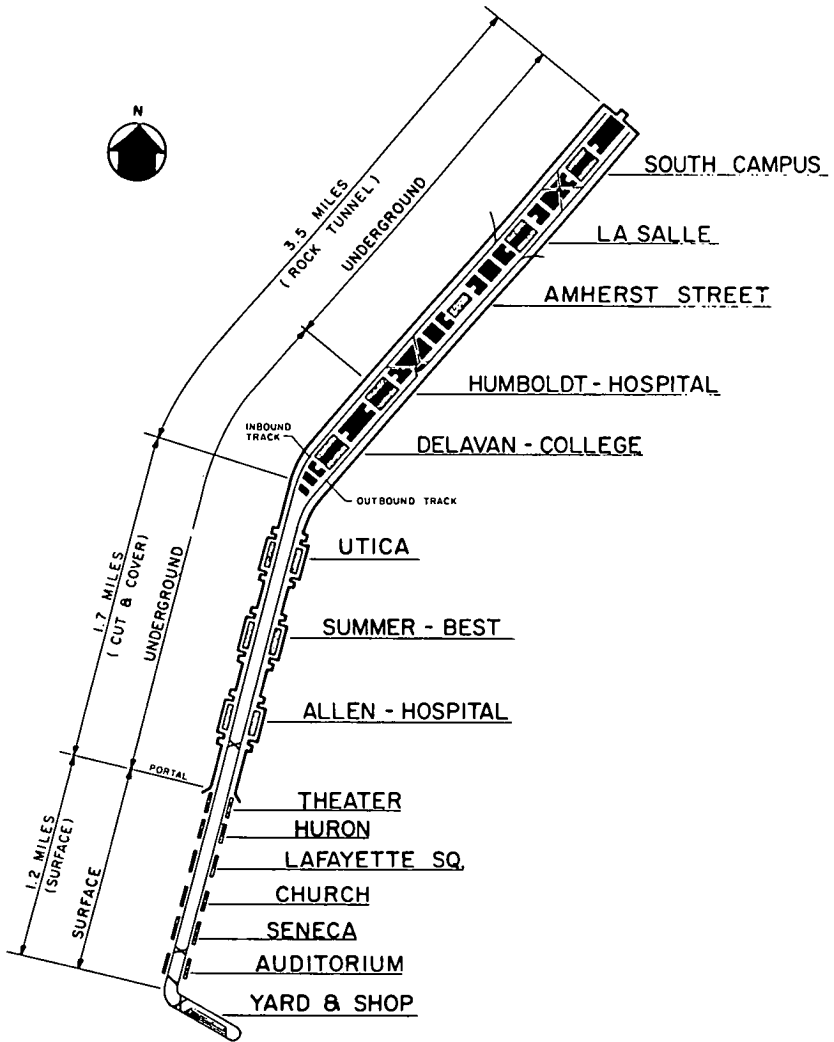


FIGURE 1 Buffalo system overview.

The line goes underground at Theatre Station and runs to South Campus Station. The first 1.7 mi of underground operations has been constructed by the cut-and-cover method. In this section the surface of Main Street was excavated and a concrete box built below through which the trains operate. The excavation was then filled and the street surface repaved. There are three passenger stations in the cut-and-cover section. The remaining 3.5 mi of the line was machine-bored into twin tunnels through solid rock. Five passenger stations are located in this section.

Loading underground is from 300-ft floor-level platforms (i.e., high-level loading). The system therefore requires a bilevel loading car. The folding steps are not utilized in the underground sections.

The Buffalo light rail vehicle (LRV) is a four-axle double-ended unit 66.8 ft long. Each car has 51 seats and can comfortably accommodate 140 passengers, standing and seated, during rush hour. The maximum crush load capacity is 210 passengers. Each car has three sliding doors and retractable steps for surface boarding on both sides of the car. Underground train speed varies up to a maximum of 50 mph. On the surface section train speed is restricted to a maximum of 28 mph due to pedestrian traffic.

Table 1 shows the carbody features of Buffalo's LRVs. The major LRV subsystems are detailed in the Appendix to this paper.

## **PROCUREMENT**

In mid-1979, the Niagara Frontier Transportation Authority (NFTA) decided to use the two-step procurement process for purchasing their LRVs. The first step involved producing a request for technical proposals (RFTP). Nine car builders responded. In June 1980, five of the original nine respondents submitted technical proposals. Following NFTA's acceptance of the five final technical proposals, fixed-price bids were requested. NFTA allowed respondents to propose bids for both six-axle articulated cars and four-axle cars. Details on passenger capacity for the proposed cars and operational requirements were known. Thus, NFTA was able to specify a fleet size for each bidder. The bids are summarized in Table 2.

Tokyu Car Corporation (TCC) of Yokohama, Japan, was the low bidder. NFTA authorized the purchase of 27 vehicles under the two-step procurement method already discussed.

## **MAINTENANCE TRACKING SYSTEM**

The car builder was required to catalog certain data so that the rail car could be evaluated with respect to maintainability and reliability requirements. A

TABLE 1 CARBODY FEATURES

Feature	Details
Manufacturer	Tokyu Car Corp.
Length over couplers	66 ft 10 in.
Width (across rubrails)	8 ft 7 in.
Roof height	11 ft 3 in.
Pantograph lockdown height	12 ft 3 in.
Underground contact wire height	12 ft 11 in.
Seats/seat width	51/19 in.
Door height/width (3 per side)	6 ft 3 in./45 in.
Floor	Stainless steel-clad plywood
Floor insulation	Ceramic fiber (Fiberfrax)
Emergency intercoms (to operator)	2
Wheelchair lockdowns	2
Floor height	
(AWO)	37.2 in.
(AW3)	36.8 in.
Headroom, center aisle	6 ft, 11 in.
Empty weight	70,000 lb
Usable standee space	237 ft
Door/step pushbuttons	2 per door
Fire extinguishers	2 per car
Air conditioning (safety electrical)	13.5 tons per car
Noise levels	
Inside	Spec.: 72 dBA @ 50 mph; test: 66 dBA
Outside	Spec.: 80 dBA @ 50 mph; test: 76 dBA (50 ft)

TABLE 2 NFTA LRV BID PRICE COMPARISON

Bidder	Fleet Size	Car Type	Deviation from Low Bid (%)
Tokyu (TCC)	33	4-axle	0
UTDC	33	4-axle	+14
Siemens	27	6-axle	+16
Bombardier	25	6-axle	+21
Hawks-Sido	25	6-axle	+38

work order system was developed to monitor failures in service, failures found during preventive maintenance checks, and failures discovered during system checks.

If an in-service failure occurs, the operator logs the symptom on a defect card. This card is then submitted to the maintenance department at the

completion of the operator's run. The maintenance department then makes any necessary repairs and completes a work order.

The system check form, which is a daily check of the vehicle's operating system, is also used, but is completed prior to the vehicle's release for service. Any failures discovered during this check are a second source of information that is also entered into the work order system. A third source of information is the preventive maintenance check form.

The work order system provides a history of the vehicle categorized by subsystem. It estimates repairs, distances traveled between failures, and parts utilized to perform repairs. Each work order is numbered sequentially and logged with a brief description of the failure. This log is essential for traceability of the completed work order.

The work order system was developed further on the introduction of an IBM AT computer system. Using the dBASE III software package, an input form was designed that is similar to the written work order form. Work orders now can be entered into a data base.

## SUMMARY OF OPERATIONS

Full revenue service began November 1986. To accommodate passenger service, 23 cars are required daily during the peak rush hours. Figures 2 and 3 reflect the service requirements and fleet availability to meet those requirements during 1986 and 1987. Percent availability is computed by the number of vehicles that can be made ready for service. Percent service is based on maintaining car requirements to satisfy passenger loading. Both graphs were computed from monthly operating days using the following formulas:

$$\text{Percent service} = \frac{\text{No. of cars in service}}{\text{No. of cars required for service}} \times 100$$

$$\text{Percent availability} = \frac{\text{No. of cars available for service}}{\text{No. of cars in fleet}} \times 100$$

Out of the four cars not required for passenger service, three are required for preventive maintenance. The remaining car is used as a spare for revenue service. The preventive maintenance schedule is based on monthly checks of each car's subsystems. Discrepancies discovered during the preventive maintenance checks have reduced operating failures to a minimum, which is reflected in NFTA's ability to maintain service requirements.

One problem area during the first year of operation was the step assemblies. There were two to three step-related failures per day. NFTA worked

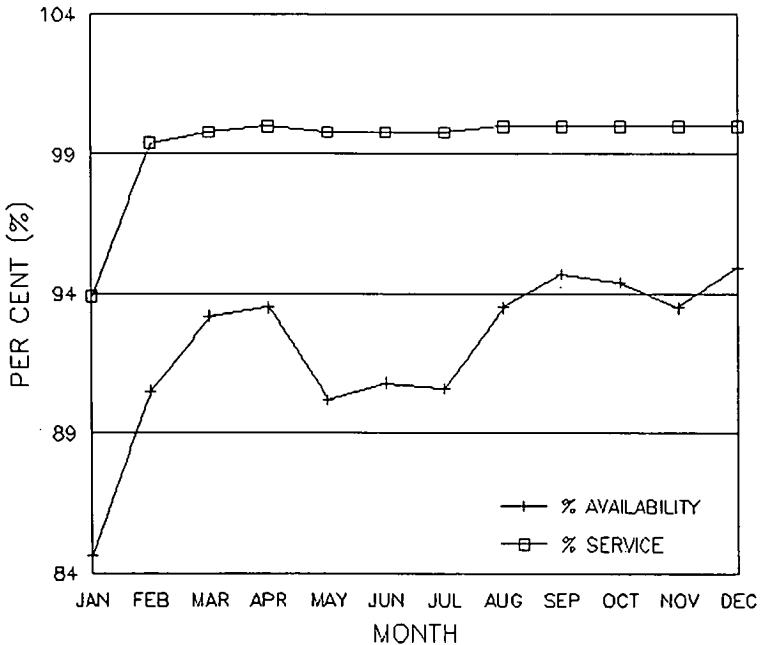


FIGURE 2 Service and fleet availability, 1986.

with the manufacturer to put the step assembly through a series of modifications that improved its performance. Internal bracing was required to prevent fatigue failure. Brass bushings and grease fittings replaced oil light steel bushings on hinge points to reduce binding. These two modifications improved step performance with a failure rate of less than two failures per week of operating time.

## CONCLUSION

Since the line opened in May 1985, more than 2 million vehicle fleet miles have been accumulated. This equals approximately 75,000 mi per vehicle. In 1987, under full revenue service, 35,000 mi per vehicle was accumulated.

As Figure 3 shows, the service requirements for the 23 cars have been met over 99 percent of the time in 1987. This was accomplished by having over 95 percent of the total fleet (27 cars) available at any one given time.

Two factors have helped meet these requirements. The first is the vehicle system. Part replacement can be accomplished with minimum down time through the use of quick connectors, parts interchangeability, and an ample supply of spare parts.

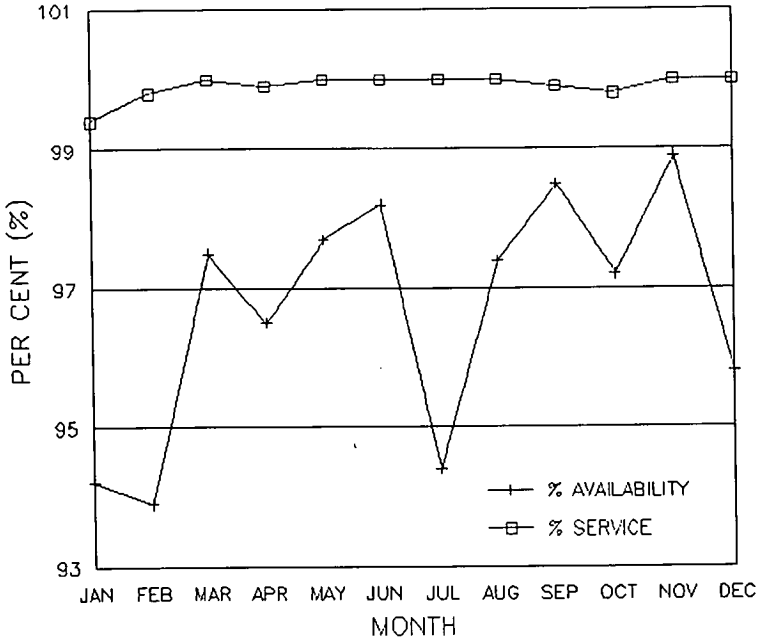


FIGURE 3 Service and fleet availability, 1987.

The second factor is the maintenance employees' familiarity with the vehicle. As the employees become familiar with the different LRV systems, they become more proficient in trouble-shooting defects. This has contributed to the reduction of down time due to failures.

It appears that Tokyu's cars have been a sound investment for NFTA. The vehicles are easily maintained and have been found to be mechanically sound. The preventive maintenance program as well as the maintenance employees' skill are also major factors in the system's reliability.

Two drawbacks of the vehicles can be attributed to funding and procurement regulations. The LRV has both foreign and American parts, which makes parts procurement both difficult and costly. Also, after the expiration of the warranty, communicating with the manufacturer became very difficult when it was necessary to discuss problems regarding the vehicles.

If NFTA were to purchase more cars under the same procurement process, two improvements could be made. First, maintenance personnel should be involved in the discussion of system requirements. Second, a close evaluation of the spare parts that may be required to support the system should be made. These parts should be ordered as part of the vehicle procurement process.

## APPENDIX: BUFFALO RAILCAR SUBSYSTEMS

### PROPULSION (Westinghouse)

- \* Four 1463D Motors/Car, Force Ventilated
  - \* Nominal 650 Vdc Traction Power
  - \* 310V, 343a, 2400 rpm, 135 hp (Cont. Rating)
  - \* Chopper Control
    - \* Two Truck Motors in Series, Two Trucks in Parallel
  - \* Max. Operating Speed: 50 mph (28 mph on Surface)
  - \* Base Speed: = 21.5 mph
  - \* 37.5Vdc Auxiliary Power
  - \* Dynamic Braking
  - \* Regeneration
  - \* Spin/Slide Control
  - \* Four WR-101-3 Gearboxes
    - \* Parallel Drive, Double Reduction, 7.130 Ratio
  - \* Batteries (McGraw-Edison)
    - \* NiCad - MED 189
    - \* Twenty five 1.4V cells
    - \* 189 Amp/Hr.
  - \* Acceleration (AW2 @ 650 V)
- | <u>Spec.</u>             | <u>Test</u> |
|--------------------------|-------------|
| *Avg: 2.3 mphps (min.)   | 2.85        |
| *Time to 50 mph: 37 sec. | 35          |

### TRUCKS (Tokyu Car Corp.)

- \* Primary Suspension: Chevron
- \* Secondary Suspension: Air Bag
- \* Track Gauge (Tangent Track): 4' 8-1/4"
- \* Truck Center Distance: 36' 2"
- \* Wheelbase: 6' 2"
- \* Wheels: AREA Plan 793-52, except for thickness, Ring damped
- \* Wheel Diameter: 26"
- \* Load Leveling
- \* Max. Axle Load: 29,300 lbs.

### BRAKES (Knorr Brake)

- \* Disc: Spring Applied, Air Release
  - \* Brake Blending: Dynamic to Friction = 10 mph (AW2)
  - \* Anti-Rollback: Manual, 7% grade
  - \* Track Brake: 37.5 Vdc/29.7a, 2000 lbs. @ 50 mph
  - \* Full Service: Blended, Jerk Limited
  - \* Emergency: Friction plus Track + Sand
  - \* Deceleration (AW3 @ 650 V, 50 mph)
- | <u>Spec.</u>                     | <u>Test</u> |
|----------------------------------|-------------|
| *Friction: 3.0 mphps + 15%       | 2.55        |
| *Service: 3.0 mphps + 10%        | 3.0         |
| *Emergency: V/ (gross) 4.0 mphps | 4.35        |

### COUPLER (Dellner-Schaku)

- \* Type 34
- \* Gathering Range: Hor. + 5.9", Ver. +3.2"
- \* Draft Gear: Elastic Range 46000#/in.  
Plastic Range 90000# (constant) over 12"

### PANTOGRAPH (Stemmann)

- \* BS-80, Single Arm, Dual Brushes
- \* Spring Up, Power Down (Pneumatic)
- \* Contact Force, Static: 18 lb. + 5%
- \* Brush Width: 41.3"
- \* Bow Width: 66.9"



DOORS (Panel: Tokyu Car, Mechanism: Faiveley)

STEPS (Faiveley)

- \* Enable Mode: Manual, Passenger pushbuttons, all doors, inside and outside (Inoperative Underground)
- \* Normal Modes:
  - \* Open/Close: Left/Right
  - \* Open All Doors
  - \* Close All Doors
- \* Doors/Steps Air Actuated
- \* Door Open Indicator Lights
  - \* One each side - Outside
  - \* Three each Cabin
- \* Operating Times
  - \* Step Down/Door Open: 5 sec.
  - \* Door Close/Step Up: 6 sec.
- \* Sensitive Edges: On door edge  
On edge of first step

WINDOWS (Ellcon National Inc.)

- \* Nine per side - Four with Transoms
- \* Tinted Safety Glass (Windshield is Clear)
- \* Transmissibility: 69%